Perioperative Use of Anticoagulant and Platelet-inhibiting Medications for Elective Spine Surgery: Results of a Nationwide Survey

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Abstract: BACKGROUND AND STUDY AIMS Perioperative use of anticoagulant and platelet-inhibiting agents by patients undergoing spine surgery poses the dilemma of increased risk of hemorrhage. We examined the standards of use for these medications and expert opinions through a nationwide survey. MATERIALS AND METHODS An online-based survey was conducted by invitation. A personal token to access the survey was sent to one representative of each neurosurgical and orthopaedic unit performing spine surgery and to all other active members of the Swiss Society of Neurosurgery and the Swiss Society of Spinal Surgery. A total of 97 e-mail invitations were sent to 19 representatives of neurosurgical or orthopaedic units and 78 registered neurosurgeons and orthopaedic surgeons who potentially perform spine surgery. RESULTS From February to April 2016, 40 surgeons (26 neurosurgeons, 14 orthopaedic surgeons) completed the survey (41%). Among the respondents, 55% prescribed prophylactic heparin preoperatively; depending on the procedure, 83 to 95% prescribed heparin postoperatively. Depending on the type of surgery, 23 to 48% discontinued acetylic acid preoperatively, and 80 to 87% always discontinued clopidogrel preoperatively. On average, platelet inhibition was resumed 4 ± 2.5 days postoperatively. Orthopaedic surgeons recommenced platelet inhibition earlier than neurosurgeons (= 0.013). Anticoagulation with rivaroxaban was discontinued 3 ± 2 days before surgery. Depending on the indication, 72 to 98% of respondents temporarily replaced traditional anticoagulation therapy (vitamin K antagonists) with heparin perioperatively. CONCLUSION Administration and discontinuation of anticoagulant and platelet-inhibiting medications in the perioperative setting of spinal surgery differ vastly between different units and surgeons. Recommendations from the spine surgeon societies may be helpful to develop nationwide guidelines.

DOI: https://doi.org/10.1055/s-0037-1615295

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J Neurol Surg A

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Keywords
- anticoagulation
- platelet inhibition
- spine
- surgery

received
April 25, 2017
accepted after revision
September 8, 2017

DOI https://doi.org/10.1055/s-0037-1615295.
ISSN 2193-6315.

Introduction

Perioperative use of anticoagulant and platelet-inhibiting agents by patients undergoing spine surgery poses the dilemma of increased risk of hemorrhage as opposed to an increased risk of thrombosis or complications by discontinuing patients' anticoagulant or platelet-inhibiting medications. The management of perioperative anticoagulant and platelet-inhibiting agents for patients undergoing spine surgery is a widely discussed topic. Studies have discussed the controversial topic of increased risk of perioperative hemorrhage in patients undergoing treatment with platelet-inhibiting agents or low-molecular-weight heparin (LMWH). The incidence of perioperative hemorrhage reportedly ranges from 0.1% to 1%.[1,2] The study of the risk factors of perioperative hemorrhage is difficult because of the rarity of this complication, thereby leading to contradictory results. Although some studies report no risk of perioperative hemorrhage with the use of platelet-inhibiting agents or LMWH,[1,3–7] others indicate a risk.[8–10]

Another controversial topic in the literature pertains to the use of LMWH to prevent venous thromboembolic diseases after spinal surgery. The incidence of deep vein thrombosis (DVT) in spinal surgery patients is reported to be 0.3 to 31%, depending on the patient population and the method of surveillance, and it has been reported to be considerably lower than that for patients undergoing major lower extremity surgery.[11,12] Therefore, some studies have reported no need for postoperative LMWH after spinal surgery.[13,14] Others, however, have reported a decreased incidence of venous thromboembolism after spine surgery.[4,7,15]

Survey questionnaires are an excellent tool for examining current trends and expert opinions. Previous survey studies of perioperative platelet inhibition or anticoagulation date back to at least 2012, and they were limited to thromboprophylaxis for spinal surgery, such as the studies by Glotzbecker et al and Bryson et al,[13,16] and perioperative use of low-dose aspirin for spinal surgery, such as the study by Korinth et al.[17] None of these surveys covered the more recent issue of new oral anticoagulants for patients undergoing spinal surgery, therapeutic anticoagulation in general, or bridging anticoagulation. Many recent studies of anticoagulation and platelet inhibition in patients undergoing spinal surgery have been published and might have changed the practice of spinal surgeons.[2–10]

Previous studies have yielded contradictory results, and the recommendations for perioperative management with anticoagulant and platelet-inhibiting agents for patients undergoing spine surgery are inconsistent. Therefore, the aim of this study was to examine the standards of use for these medications and expert opinions about the subject.

Material and Methods

An online survey was created using the open source survey tool LimeSurvey, v.2.05 + . The questionnaire was composed of 20 questions in four groups covering surgeon experience with spine surgery, perioperative use of thrombosis prophylaxis for spinal surgery, and perioperative management with anticoagulation and platelet inhibition (Appendix A). The survey was translated into German and English and uploaded to http://spinesurvey.limequery.org. Access was provided by invitation through an e-mail with a token-activated link. The response values were stored separately from the list of respondents and Internet protocol addresses.

A list of surgeons involved in spine surgery was obtained from a list (published online) of all members of the Swiss Neurosurgical Society (www.swissneurosurgery.ch), a mailing list from the Swiss Society of Spinal Surgery, and a comprehensive Internet search of all public and private hospitals in Switzerland employing orthopaedic surgeons offering spinal surgery. The original list contained 160 surgeons.

For all large neurosurgical or orthopaedic units with 24-hour emergency service ($n = 19$), one representative of each neurosurgical and orthopaedic unit who performed spine surgery was chosen. Most large departments have departmental policies for the discontinuation and recommencement of anticoagulant and platelet-inhibiting medications for spinal surgery patients. One survey study among neurosurgeons in Germany in 2007 found that 80.3% of responding neurosurgical units had a written departmental policy regarding the discontinuation of preoperative acetylic acid treatment.[17] Other doctors on the societies' lists employed at these units were excluded because the spine units were assumed to have uniform standards for perioperative use of anticoagulant and platelet-inhibiting medications. Active in-patient doctors working in private practice and those who were members of the Swiss Society of Neurosurgery and the Swiss Society of Spinal Surgery were also asked to participate in the present survey.

After the exclusions just described and four additional exclusions due to no available valid e-mail, a list of 110 invitees was uploaded to LimeSurvey. One invitation and up to five reminder e-mails were sent from February to April 2016.

SPSS software v.21 (SPSS Statistics 2010, Chicago, Illinois, United States) was used for qualitative and quantitative analyses of the data. Data were split into groups based on specialty (neurosurgeons and orthopaedic surgeons). Data of the respondents were analyzed using the Fisher exact test and various nonparametric tests (Wilcoxon rank sum/Kruskal-Wallis and median test) according to the data type and characteristic. Statistical significance was set at $p \leq 0.05$.

The present article was prepared in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement checklist for cross-sectional studies.[18]

Results

The response rate was 74% for unit representatives and 33% for surgeons in private practice (►**Fig. 1**). Twenty-six neurosurgeons and 14 orthopaedic surgeons completed the questionnaire. The mean experience with spine surgery

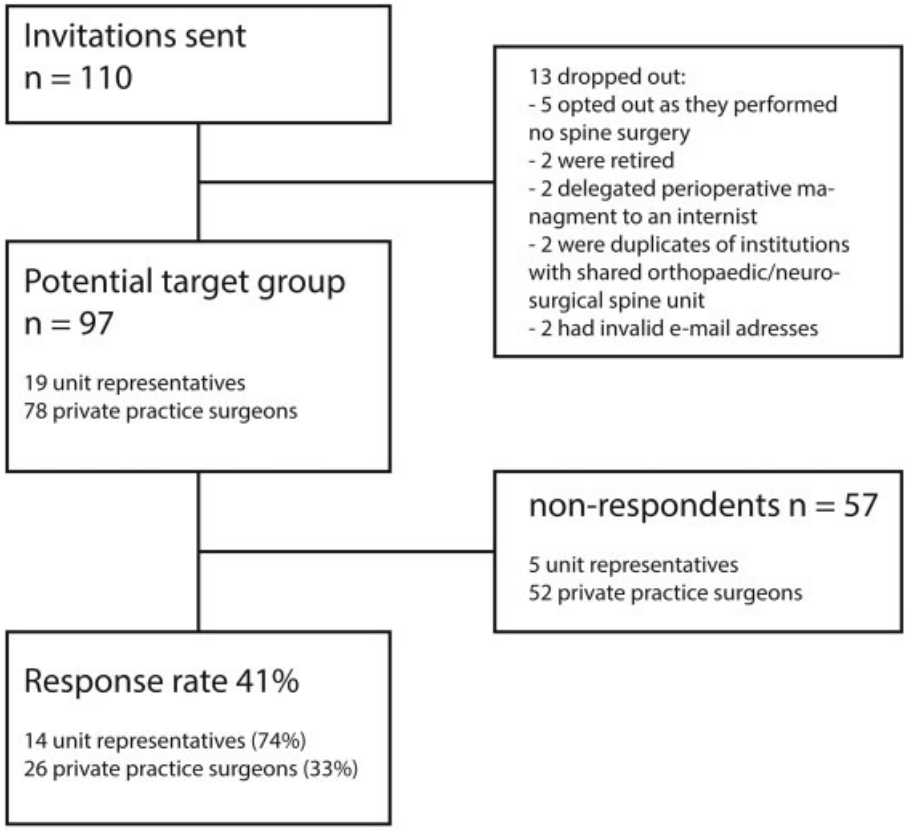

Fig. 1 Inclusion/Exclusion flowchart.

was 17.5 ± 9.3 years for orthopaedic surgeons and 14.5 ± 9.7 years for neurosurgeons (15.6 ± 9.5 years overall). The mean number of spinal surgeries per year was 263 ± 118 (range: 100–500) for orthopaedic surgeons and 185 ± 107 (range: 10–500) for neurosurgeons (214 ± 116 overall; range: 10–500).

Thrombosis Prophylaxis

Twenty-two surgeons (55%) prescribed LMWH on the evening before surgery. There was no significant difference between neurosurgeons and orthopaedic surgeons (58% versus 50%, respectively; $p = 0.462$). Twenty-nine respondents (73%) prescribed compression stockings as part of the postoperative routine for the prevention of thromboembolism after spinal surgery. Regarding specific medication for thrombosis prophylaxis, multiple answers were possible. Nadroparin (Fraxiparine; Aspen Pharma, Durban, South Africa) was prescribed by 20 (50%), enoxaparin (Clexane; Sanofi-Aventis, Paris, France) was prescribed by 18 (45%), rivaroxaban (Xarelto; Bayer Pharma, Berlin, Germany) was prescribed by 7 (18%), unfractionated heparin was prescribed by 4 (10%), and dalteparin (Fragmin; Pfizer, Pearl River, New York, United States) was prescribed by 3 respondents (8%).

Medical thrombosis prophylaxis was recommenced postoperatively for lumbar decompression or lumbar spondylodesis by 38 respondents (95%) and after cervical decompression by 33 (83%). Twenty-eight surgeons (70%) responded that medical thrombosis prophylaxis was started 6 hours after surgery or during the evening of the day of surgery, and 10 (25%) responded that it was started on the first postoperative day. LMWH was prescribed by 31 (82%); rivaroxaban was prescribed by 7 (18%). Five surgeons (13%) administered thrombosis prophylaxis until the patient was ambulatory, 29 (76%) administered it until discharge, 2 (5%) administered it until 1 week postdischarge, and 2 (5%) administered it $>$ 1 week postdischarge. No significant differences were noted between neurosurgeons and orthopaedic surgeons regarding the thrombosis prophylaxis prescribed.

Platelet Inhibition

►**Table 1** provides the data regarding the practice of preoperative discontinuation of platelet inhibition. Platelet inhibition was discontinued more often before surgeries of the cervical spine than before those of the lumbar spine. At the level of the lumbar spine, platelet inhibition was discontinued more often for multilevel surgeries or before spondylodesis than for single-level decompression or diskectomy. On average, platelet inhibition was resumed 4 ± 2.5 days postoperatively, and orthopaedic surgeons started platelet inhibition (acetylic acid or clopidogrel) significantly earlier than neurosurgeons (3 ± 3 days versus 4 ± 2 days postoperatively, respectively; $p = 0.013$).

Table 1 For the following spine surgery procedures, do you always discontinue acetylsalicylic acid used for platelet inhibition?

Procedure	Do you discontinue administration of acetylic acid for platelet inhibition before the following spinal surgeries?		Do you discontinue administration of clopidogrel for platelet inhibition before the following spinal surgeries?		
	Yes	No	Yes	No	Only if double platelet inhibition
Elective lumbar herniated disk or spinal canal stenosis: 1 segment (%)	9 (23)	31 (77)	32 (80)	2 (5)	6 (15)
Elective lumbar dorsal interbody fusion: 1–2 segments (%)	17 (43)	23 (57)	33 (85)	2 (5)	4 (10)
Elective lumbar decompression: 3 segments (%)	16 (40)	24 (60)	33 (82)	2 (5)	5 (13)
Anterior cervical interbody fusion: 1–2 segments (%)	19 (48)	21 (52)	35 (87)	2 (5)	3 (8)

Therapeutic Anticoagulation with Rivaroxaban

Data regarding the practice of preoperative discontinuation of rivaroxaban are displayed in ►**Table 2**. If rivaroxaban for atrial fibrillation was discontinued, then 11 surgeons (28%) always prescribed bridging anticoagulation therapy with LMWH, 12 (30%) never prescribed bridging anticoagulation therapy with LMWH, 13 (33%) made the decision after asking an internist, and 4 (10%) answered "other." In cases of DVT/pulmonary embolism (PE) $>$ 1 year before the planned spinal surgery, bridging anticoagulation medication to replace rivaroxaban was always prescribed by 15 surgeons (38%) and was never prescribed by 8 (20%); 15 (38%) always made the decision after asking an internist. Nine (22.5%) routinely ordered serum-anti-Xa activity preoperatively, 23 (57.5%) did not, 6 (15%) ordered it depending on the patient's renal function, and 2 (5%) chose the option "other."

Traditional Anticoagulation Therapy Using Vitamin K Antagonists

Most respondents paused vitamin K antagonists ((e.g., warfarin, Coumadin) after spinal surgery for 1 to 2 weeks. When vitamin K antagonists where administered for DVT/PE $>$ 1 year previously or for intermittent atrial fibrillation, 15 to 20% of the respondents did not bridge the anticoagulation therapy. ►**Table 3** lists the detailed results regarding the question of whether respondents prescribe bridging anticoagulation therapy when oral anticoagulants are paused.

Discussion

The results of this study reveal the rather heterogeneous practice of perioperative use of anticoagulant and platelet-

Table 2 How many days before the following spinal procedures do you discontinue therapeutic rivaroxaban when it is indicated for atrial fibrillation?

Procedure	Atrial fibrillation				History of DVT or PE			
	All respondents	Neurosurgeons	Orthopaedic surgeons	*p*	All respondents	Neurosurgeons	Orthopaedic surgeons	*p*
Elective lumbar herniated disk or spinal canal stenosis: 1 segment	3.1 ± 2.0	2.6 ± 1.3	4.2 ± 2.9	0.12	3.3 ± 2.0	2.8 ± 1.3	4.5 ± 2.8	0.07
Elective lumbar dorsal interbody fusion: 1–2 segments	3.2 ± 2.0	2.6 ± 1.3	4.4 ± 2.8	0.05	3.4 ± 2.0	2.8 ± 1.3	4.7 ± 2.6	0.03
Elective lumbar decompression: 3 segments	3.2 ± 2.0	2.6 ± 1.3	4.4 ± 2.8	0.06	3.4 ± 2.0	2.8 ± 1.3	4.5 ± 2.8	0.08
Anterior cervical interbody fusion: 1–2 segments	3.1 ± 2.0	2.6 ± 1.3	4.2 ± 2.9	0.14	3.4 ± 2.0	2.8 ± 1.3	4.6 ± 2.7	0.05

Abbreviations: DVT, deep vein thrombosis; PE, pulmonary embolism.
Note: Data are presented as mean plus or minus standard deviation (days).

Table 3 In the following cases, do you use heparin while discontinuing vitamin K antagonists perioperatively?

Procedure		Yes (%)	Rather yes (%)	Rather no (%)	No (%)	95% confidence interval; *p* value[a]
DVT/PE within last 6 mo	All respondents	32 (82)	6 (15)	1 (3)	–	−0.205 to 1.227; 0.162
	Neurosurgeons	20 (77)	6 (23)	–	–	
	Orthopaedic surgeons	12 (86)	–	1 (8)	–	
DVT/PE > 1 y ago	All respondents	20 (51)	8 (21)	8 (21)	3 (7)	−0.300 to 1.538; 0.187
	Neurosurgeons	13 (50)	6 (23)	5 (19)	2 (8)	
	Orthopaedic surgeons	7 (54)	2 (15)	3 (23)	1 (8)	
Intermittent atrial fibrillation	All respondents	22 (56)	8 (21)	6 (15)	3 (8)	−0.135 to 1.659; 0.096
	Neurosurgeons	15 (58)	6 (23)	3 (11)	2 (8)	
	Orthopaedic surgeons	7 (54)	2 (15)	3 (23)	1 (8)	
Mechanical aortic valve implant	All respondents	34 (87)	4 (10)	1(3)	–	0.019–1.456; 0.044
	Neurosurgeons	23 (88)	2 (8)	1 (4)	–	
	Orthopaedic surgeons	11 (85)	2 (15)	–	–	
Mechanical mitral valve implant	All respondents	34 (87)	4 (10)	1(3)	–	0.019–1.456; 0.044
	Neurosurgeons	23 (88)	2 (8)	1 (4)	–	
	Orthopaedic surgeons	11 (84)	2 (15)	–	–	

Abbreviations: DVT, deep vein thrombosis; PE, pulmonary embolism.
[a]Ordinal regression; 95% confidence interval and significance (*p* value).
Note: Data are presented as n (%). 1 Nonrespondent for all items. *p* values for the difference between the neurosurgical and orthopaedic group.

inhibiting medications among spine surgeons. Among the respondents, 55% prescribed prophylactic anticoagulation preoperatively; there was no significant difference between orthopaedic surgeons (50%) and neurosurgeons (58%). Bryson et al reported that 31% of orthopaedic surgeons and 73% of neurosurgeons routinely used LMWH.[16] The incidence of DVT is reported to be 0.3 to 31% for patients who undergo spinal surgery.[11,12,15] One reason for the wide range in the incidence of DVT is the method used to diagnose this condition. If diagnosed with ultrasonography, there is a high incidence of asymptomatic DVT, as reported by Yamaguchi et al.[12] The symptomatic incidence of DVT is reported to be ~ 1 to 3%.[4,11,14,19]

Cox et al reported consequent chemical thrombosis prophylaxis for all patients undergoing spine surgery without an increased risk of morbidity and a DVT rate of 1%.[4] In contrast, a large review could not support or refute the use of chemical thrombosis prophylaxis in addition to compression stockings.[11] Among our respondents, 95% prescribed chemical thrombosis prophylaxis postoperatively and 73% prescribed compression stockings as part of the postoperative routine for the prevention of thromboembolism after spinal surgery. No significant differences in the use of thrombosis prophylaxis between neurosurgeons and orthopaedic surgeons were found. Regarding the time to start thrombosis prophylaxis, Strom et al recommended starting thrombosis prophylaxis 24 to 36 hours postoperatively, with a very low hemorrhage risk.[7] In a survey by Glotzbecker et al, the average time to start thrombosis prophylaxis was 48 hours after surgery.[13] Among our respondents, 70% started thrombosis prophylaxis on the day of surgery.

Only ~ 1 of 5 respondents discontinued platelet inhibition with acetylic acid before elective lumbar herniated disk or stenosis. However, most of our respondents ceased clopidogrel preoperatively. Surprisingly, even for cervical hernia surgery, less than half would cease acetylic acid preoperatively. Park et al recommended that acetylic acid should be discontinued 7 days before surgery.[10] Similarly, in the survey study by Korinth et al published in 2006, most German neurosurgeons (95%) ceased low-dose aspirin before elective spine surgery, on average, 7 days preoperatively.[17] Cuellar et al showed no appreciable increase in bleeding-related complication rates for patients with cardiac stents undergoing spine surgery who continued using aspirin compared with inpatients who discontinued aspirin before surgery.[5]

A 2016 study by Soleman et al demonstrated no increased risk of postoperative hemorrhage if acetylic acid was continued by patients who underwent noninstrumented extradural lumbar spinal surgery; they concluded that its continuation seemed safe and therefore should be recommended.[6] Another study similarly showed no increased risk of postoperative spinal bleeding, even in a subgroup who underwent double platelet inhibition with aspirin and clopidogrel.[3] These results might explain the much lower percentage of spinal surgeons who discontinued acetylic acid before elective spine surgery in the current study compared with the survey in Germany performed

10 years previously by Korinth et al.[17] If discontinued, orthopaedic surgeons reestablished platelet inhibition (aspirin or clopidogrel) $\sim$ 1 day earlier than neurosurgeons ($p = 0.013$).

Steinberg et al showed a higher rate of bleeding if bridging anticoagulation therapy was used during perioperative interruption of platelet inhibition treatment.[20] Regarding cessation of therapeutic anticoagulation with rivaroxaban, a similarly size group of respondents chose to always or never use bridging anticoagulation therapy. On average, respondents ceased therapeutic rivaroxaban slightly more than 3 days before surgery, in accordance with the manufacturer's recommendation. Orthopaedic surgeons ceased rivaroxaban earlier than neurosurgeons.

Unlike therapeutic anticoagulation with rivaroxaban and platelet inhibition, therapeutic anticoagulation with vitamin K antagonists was stopped and replaced with bridging anticoagulation therapy by most orthopaedic surgeons and neurosurgeons. This was the case for patients with mechanical aortic valve, mechanical mitral valve, and DVT/PE within the past 6 months. If the reason for vitamin K antagonist use was DVT or PE $>$ 1 year before or for atrial fibrillation, 23 to 28% would rather not prescribe bridging anticoagulation therapy, which was similar to the practice for platelet inhibitors. No difference was found for orthopaedic surgeons and neurosurgeons regarding the use of bridging anticoagulation therapy for ceased vitamin K antagonists.

Douketis et al reported no need for perioperative bridging therapy for interrupted therapeutic anticoagulation with warfarin for patients with atrial fibrillation.[8] They found that the arterial thromboembolic risk after cessation of therapeutic anticoagulation was equal to that when no bridging anticoagulation therapy was administered; however, the risk of hemorrhage was increased when bridging anticoagulation therapy was used. They also stated that the use of bridging anticoagulation therapy has been anchored to the premise that the associated higher bleeding risk was clinically acceptable because it would be offset by a lower risk of perioperative arterial thromboembolism.[8]

The main limitation of the present study was the low response rate of invitees from private practices. However, the response rate by the unit representatives was excellent for an online-based survey. The overall response rate of 41% was slightly lower than that of other surveys among spine surgeons that reported response rates of 49 to 67.6%.[13,17] The survey was performed in only one country that might have limited the generalizability of the results. The responses were anonymized so the respondents' names and the response sets were stored in different files. Therefore, the differences between the units involved in spine surgery and surgeons in the private practice could not be established.

Direct evaluation of complications (hemorrhage/DVT/PE) related to different perioperative anticoagulation practices could not be performed through a survey. These complications have a very low incidence, and the long experience of the responding surgeons did not suggest that they would continue riskier practice if they experienced higher complication rates.

This survey study adds a comprehensive overview of current practice regarding the use of anticoagulant and platelet-inhibiting medications in the perioperative setting of elective spinal surgery. To date, it is the first survey among spinal surgeons regarding this subject in the past 5 years, and it is also the most comprehensive. In contrast to previous surveys, it included the use of platelet inhibition and anticoagulation.

Furthermore, it is the first survey examining current standards for the use of new oral anticoagulants—in this case, the most widely used example is rivaroxaban—and bridging anticoagulation therapy for spinal surgery. The results were similar to those of previous survey studies of heterogeneous practice with regard to perioperative use of anticoagulant and platelet-inhibiting medications for elective spinal surgery patients. However, they also demonstrated that newer results reported in the literature might have influenced the current practice in this field even those there is still very little evidence.

Conclusions

Administration and discontinuation of anticoagulant and platelet-inhibiting medications in the perioperative setting of spinal surgery differ vastly between different units and surgeons. Recommendations or a protocol from the National Spine Surgeon Society may be helpful to develop nationwide guidelines.

Acknowledgments

The authors thank Editage (www.editage.com) for providing English language editing services.

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Survey Spine Surgery

Due to a lack of evidence, many clinical decisions in spine surgery are made based on rather than evidence. For example, for the use of thrombosis prophylaxis pre-, peri-, and postoperatively as well as the discontinuation of thrombocyte inhibitors and oral anticoagulants for elective spine surgery, no common guidelines exist.

Because a prospective randomized controlled study to examine these issues is not feasible, we conducted a survey among all spine surgeons (neurosurgeons and orthopaedic surgeons) in Switzerland. Our goal was to examine similarities and differences of expert opinions with regard to the subjects just described.

The questionnaire takes ~ 10 minutes to complete. All information will be treated confidentially, Internet protocols, e-mails, and names will be stored in a separate database from the answers.

Start

What medical specialty are you certified in?
Please choose **only one** of the following:

- ◯ Neurosurgery
- ◯ Orthopaedics
- ◯ Neurosurgery and orthopaedics
- ◯ Other

How many years of clinical experience as a certified specialist do you have?
Only numbers may be entered in this field.
Please write your answer here: __

How many spinal surgeries do you perform annually?
Only numbers may be entered in this field.
Please write your answer here: __

Thrombosis prophylaxis

Which medical thrombosis prophylaxis do you prescribe?
Please choose **all** that apply:

- ☐ Fraxiparin
- ☐ Clexane
- ☐ Xarelto 10 mg
- ☐ Liquemin
- ☐ Other:

Are compression stockings a part of your spinal surgery patients' postoperative routine?
Please choose **only one** of the following:

- ◯ Yes
- ◯ No

For the following spinal procedures, do you prescribe prophylactic low molecular heparin on the evening presurgery?

Please choose the appropriate response for each item:

	Yes	Uncertain	No
Elective lumbar removal of herniated disk or decompression (1 segment)	◯	◯	◯
Elective lumbar interbody fusion (1–2 segments)	◯	◯	◯
Elective lumbar decompression 3 segments	◯	◯	◯
Elective anterior cervical diskectomy (1–2 segments)	◯	◯	◯

For the following spine surgery procedures, do you prescribe prophylactic low molecular heparin postoperatively?

Please choose the appropriate response for each item:

	Yes	Uncertain	No
Elective lumbar removal of herniated disk or decompression (1 segment)	○	○	○
Elective lumbar interbody fusion (1–2 segments)	○	○	○
Elective lumbar decompression 3 segments	○	○	○
Elective anterior cervical diskectomy (1–2 segments)	○	○	○

After straightforward elective spine procedures, when do you begin prophylactic low molecular heparin?

Please choose **only one** of the following:

- ○ 6 h postsurgery
- ○ The evening after surgery
- ○ The evening of the first postoperative day
- ○ Other

For elective spine procedures, when do you start Xarelto (Rivaroxaban) postoperatively?

Only answer this question if the following conditions are met:

Answer was 'Xarelto 10 mg' at question '4 [Medi]' (Which medical thrombosis prophylaxis do you prescribe?)

Please choose **only one** of the following:

- ○ 6 h postsurgery
- ○ The evening of the day of surgery
- ○ The evening of the first postoperative day
- ○ Change from low molecular heparin to Xarelto on the day of discharge
- ○ Other

When do you cease postoperative prophylactic low molecular heparin?

Please choose **only one** of the following:

- ○ When the patient is ambulatory
- ○ When the patient is discharged home
- ○ Up to 1 wk postdischarge
- ○ Later than 1 wk postdischarge
- ○ Other

Platelet-inhibiting medications

For the following spine surgery procedures, do you always discontinue acetylsalicylic acid used for platelet inhibition?

Please choose the appropriate response for each item:

	Yes	No
Elective lumbar removal of herniated disk or decompression (1 segment)	○	○
Elective lumbar interbody fusion (1–2 segments)	○	○
Elective lumbar decompression 3 segments	○	○
Elective anterior cervical diskectomy (1–2 segments)	○	○

Do you discontinue Clopidogrel (Plavix) before the following spine procedures?

Please choose the appropriate response for each item:

	Yes	No	Only if patients have aspirin and Plavix
Elective lumbar herniated disk removal or decompression (1 segment)	○	○	○
Elective lumbar interbody fusion (1–2 segments)	○	○	○
Elective lumbar decompression 3 segments	○	○	○
Elective anterior cervical diskectomy (1–2 segments)	○	○	○

When do you usually restart platelet inhibition postoperatively (in days)?
Only an integer value may be entered in this field.
Please write your answer here: __

Oral anticoagulation

How many days before the following spinal procedures do you discontinue therapeutic Rivaroxaban (Xarelto) when it is indicated for atrial fibrillation?

Please choose the appropriate response for each item:

	1	2	3	4	5	6	7	8	9	10
Elective lumbar removal of herniated disk or decompression (1 segment)	○	○	○	○	○	○	○	○	○	○
Elective lumbar interbody fusion (1–2 segments)	○	○	○	○	○	○	○	○	○	○
Elective lumbar decompression 3 segments	○	○	○	○	○	○	○	○	○	○
Elective anterior cervical diskectomy (1–2 segments)	○	○	○	○	○	○	○	○	○	○

If you discontinue Xarelto in patients with atrial fibrillation, are you prescribing low molecular heparin temporarily?
Please choose **only one** of the following:

- ○ Yes
- ○ No
- ○ I always consult a internist
- ○ Other

How many days before the following spinal procedures would you discontinue therapeutic Xarelto in patients with a history of deep vein thrombosis (DVT) or pulmonary embolism (PE) in the past?

Please choose the appropriate response for each item:

	1	2	3	4	5	6	7	8	9	10
Elective lumbar removal of herniated disk or decompression (1 segment)	○	○	○	○	○	○	○	○	○	○
Elective lumbar interbody fusion (1–2 segments)	○	○	○	○	○	○	○	○	○	○
Elective lumbar decompression 3 segments	○	○	○	○	○	○	○	○	○	○
Elective anterior cervical diskectomy (1–2 segments)	○	○	○	○	○	○	○	○	○	○

Do you preoperatively measure serum anti-Xa-activity when Xarelto is discontinued according to the manufacturer's recommendations?
Please choose **all** that apply:

- ☐ Yes
- ☐ No
- ☐ Depending on the kidney function of the patient
- ☐ Other:

When discontinuing therapeutic dose Xarelto preoperatively in patients with history of DVT/PE (>1 year ago), do you use low molecular heparin as a temporary replacement?
Please choose **only one** of the following:

- ◯ Yes
- ◯ No
- ◯ Always consulting an internist
- ◯ Other

For how long after the following spinal procedures do you discontinue oral anticoagulants (Marcoumar, warfarin)?

Please choose the appropriate response for each item:

	<1 wk	1–2 wk	2–3 wk	3–4 wk	> 4 wk
Elective lumbar herniated disk or decompression (1 segment)	◯	◯	◯	◯	◯
Elective lumbar interbody fusion (1–2 segments)	◯	◯	◯	◯	◯
Elective lumbar decompression 3 segments	◯	◯	◯	◯	◯
Elective anterior cervical diskectomy (1–2 segments)	◯	◯	◯	◯	◯

In the following cases, do you use heparin while discontinuing Vitamin K antagonists perioperatively?

Please choose the appropriate response for each item:

	Yes	Rather yes	Rather no	No
If for the indication deep vein thrombosis (DVT)/pulmonary embolism (PE) within the last 6 mo	◯	◯	◯	◯
if for the indication DVT/PE > 1 y in the past	◯	◯	◯	◯
if for the indication intermittent atrial fibrillation	◯	◯	◯	◯
if for the indication mechanical aortic valve implant	◯	◯	◯	◯
if for the indication mechanical mitral valve implant	◯	◯	◯	◯